FILTRATION AND MAINTENANCE CONSIDERATIONS FOR SDI SYSTEMS

Todd P. Trooien, Mahbub Alam, Freddie R. Lamm
Kansas State University

Introduction

All irrigation systems require proper maintenance and subsurface drip irrigation (SDI) systems are no exception. The major cause of failures in SDI and other microirrigation systems worldwide is clogging. The emitters in SDI systems are small, leaving a small margin for error, so it is important to understand the filtration and maintenance requirements of SDI systems and take a proactive approach to the prevention of clogging.

Fortunately, most SDI users in the Great Plains are pumping from high-quality groundwater, such as the Ogallala aquifer, reducing the potential for clogging. Even so, proper steps must be taken to prevent clogging and maintain effective SDI system operation. With proper precautions and maintenance, SDI also can be used with surface water and other, lower quality, waters.

Prevention of clogging and proper maintenance of the SDI system start before it is installed. Chemical and biological analysis of the irrigation water will indicate which preventative filtration measures may be required to prevent clogging. Dripline requirements may also play a role in the selection of filtration measures to employ. Proper placement and use of flow meters and pressure gauges are required to provide feedback to the system operator. Monitoring the flow meters and pressure gauges over time can reveal system performance anomalies that may require attention. Check valves, air vents, and vacuum relief valves may be required at various places in the system to prevent entry of chemically treated water into the water source and soil particles into the driplines. Also, flushlines are required to occasionally remove the material accumulated in the driplines.

Clogging hazards for SDI systems, regardless of the water source, fall into three general categories: physical, chemical, and biological. This paper will discuss prevention of clogging problems in these three categories with special emphasis on how they apply to SDI systems in the Great Plains.

Comments or questions should be directed to Dr. Todd P. Trooien, Research Agricultural Engineer, KSU Southwest Research-Extension Center, 4500 East Mary St., Garden City, KS 67846-9319. Voice: 316-276-8286. Email: ttrooien@oznet.ksu.edu.

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Physical clogging hazards

Physical clogging hazards are usually removed with screen filters. Sizing of screen filters is based on the maximum particle size allowable by the designed SDI system, quality of the irrigation water, the flow amount between required cleanings, and the allowable pressure drop across the filter. The maximum allowable particle size should be available from the dripline manufacturer. If not, a rule of thumb is to use 0.1 times the smallest diameter in the emitters used. A 200-mesh screen filter will remove the fine sand and anything larger, and is usually adequate for SDI systems in the Great Plains. Flow rates through screen filters should not exceed 200 gpm per square foot of effective filter area. The effective filter area is defined as the area of the openings in the filter screen. Screen filters should be cleaned (backflushed) when the pressure drop across the filter increases by 3 to 5 psi or as recommended by the filtration system manufacturer. Automatic flushing is available on some filtration systems.

Also available are self-cleaning screen filters called "spin filters." These are continuous-flushing units. They swirl the water inward. Filtered particles move to the bottom of the filter and eventually leave the bottom of the filter through an open hole. A small amount of water is continuously pushing the filtered particles out the bottom and is therefore lost from the irrigation systems.

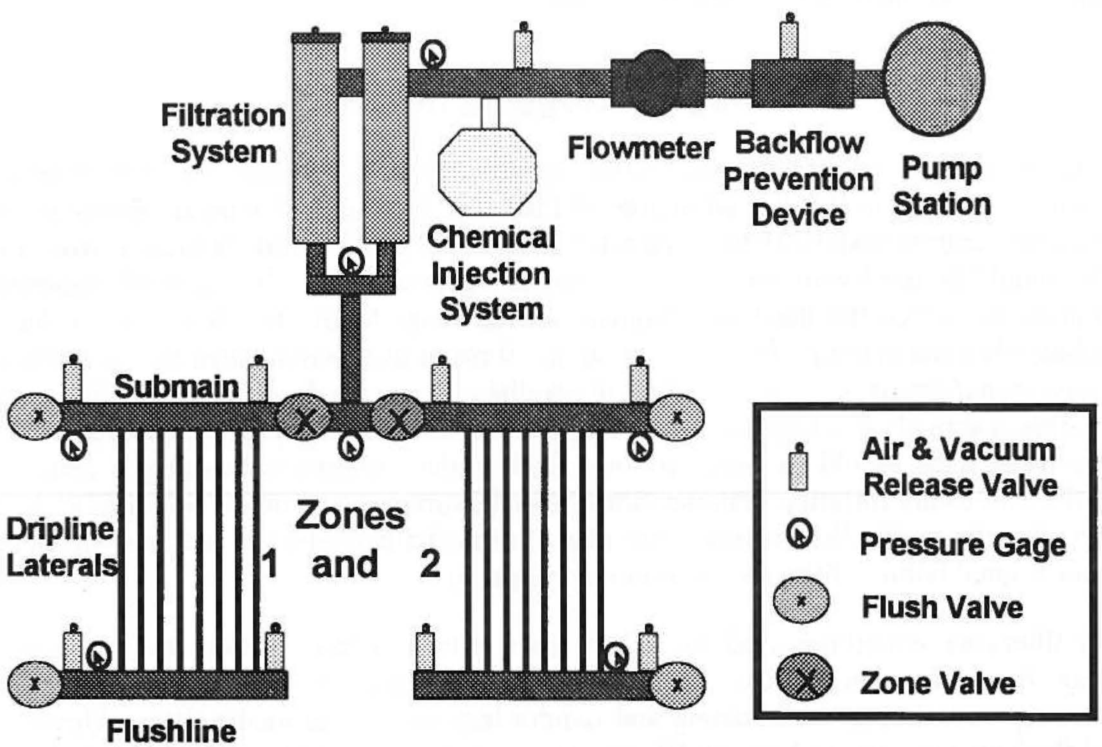

Figure 1. Schematic of a subsurface drip irrigation (SDI) system.

Table 1. Screen filter opening sizes.

Mesh	Inches	mm	Microns
40	0.017	0.425	425
100	0.006	0.150	150
150	0.004	0.105	105
200	0.003	0.075	75
270	0.002	0.053	53
400	0.0015	0.038	38

Table 2. Selected equivalent diameters.

Particle	Diameter, mm
Coarse sand	0.50 to 1.00
Fine sand	0.10 to 0.25
Silt	0.002 to 0.05
Clay	< 0.002
Bacteria	0.0004 to 0.002
Virus	< 0.0004

If large amounts of sand are in the water, a sand separator (also called a vortex sand separator or cyclone sand separator) may be required. Sand separators swirl the water and the centrifugal force separates the sand and other heavy particles from the water. If the amount of sand in the irrigation water is small, screen filtering will usually be adequate and a sand separator will not be required.

For surface water, other steps may be required. For water with a large silt concentration, a settling basin may be required to remove the silt. Also for surface waters, pre-screening of the water to remove debris such as but not limited to stalks, leaves, and other plant residue may be required. When surface water is used for SDI, more extensive filtration systems such as media filters may be desirable.

Biological clogging hazards

Sand media filters are usually used to filter organic materials. Particle size of the media is selected according to the desired degree of filtration. Flow rates for media filters should not exceed approximately 25 to 28 gpm per square foot of filter surface area. Lower flow rates should be used with water sources containing greater than 100 ppm of suspended material, to reduce the need for frequent backflushing. Media filters should be back-flushed when the pressure drop reaches about 10 psi or as recommended by the filtration system manufacturer. Use of two filters in parallel allows backflushing of one filter while the other is actively filtering the water. Backflushing flow rates depend on the media size; lower flow rates should be used for finer filter media. Automatic flushing is generally required on media filtration systems. Some manufacturers recommend the use of a screen filter after the media filter to reduce the hazard of media clogging the SDI system should a catastrophic failure of the media filtration system occur.

Disk filters are sometimes used, also. They are a hybrid of screen filters and sand media filters. Water flows in microscopic grooves between disks that filter the particles. Disk filters separate during backflushing and require less water than media filters. However, backflushing pressure as high as 50 psi may be required, which may require use of a booster pump. A typical recommended flow rate for filtering groundwater with 200-mesh-equivalent disk filters is 50 gpm per square ft of filter area.

Table 3. Sand media size and screen mesh equivalent.

Sand No.	Effective Sand Size (in)	Screen Mesh Size
8	0.059	70
11	0.031	140
16	0.026	170
20	0.018	230
30	0.011	400

Chlorine injection is usually used to assure that any unfiltered biological material does not accumulate elsewhere in the SDI system. If the microbiological load of the irrigation water is high, a low concentration (1 to 2 ppm) of chlorine should be injected continuously. If the biological load is not particularly high, a single clogging problem is severe, or biological clogging problems are due to sources other than irrigation water, chlorine shock treatment may be desirable. A shock treatment uses concentration of 10 to 30 ppm. Frequency and duration of shock treatments are determined by the severity of the problem.

Chlorine gas is the most effective and least expensive chlorine source for injection but is hazardous and must be used with caution. Sodium hypochlorite (liquid bleach) is safer and easy to obtain and use. It degrades over time so it should not be stored for long periods before using. Calcium hypochlorite granules or tablets are more stable than bleach but more expensive.

Chemical clogging hazards

Two major chemical clogging hazards to SDI systems in the Great Plains are precipitation of calcium carbonate ($CaCO_3$) and formation of iron ochre (slime).

Precipitation of $CaCO_3$ can occur in one of two ways- evaporation of water, leaving the salts behind, or change of solubility due to change of solution characteristics (mainly temperature or pH). Evaporation isn't usually a problem in SDI systems, but chemistry changes can cause $CaCO_3$ precipitation. As water temperature rises, $CaCO_3$ solubility decreases and may precipitate. In SDI systems, the buried driplines don't get as hot as surface-installed drip irrigation lines, so temperature-induced $CaCO_3$ precipitation is not as great a problem. Increased pH also decreases $CaCO_3$ solubility, raising the potential for precipitation. A water analysis can be used to determine the predisposition of the water source to $CaCO_3$ precipitation. If precipitation is likely to occur, acid injection is used to lower pH and decrease the propensity for $CaCO_3$ precipitation. An acid formulation of nitrogen fertilizer can be used for pH control and nitrogen fertilization concurrently.

At very low concentrations, it may be possible to keep iron in solution by adding acid to lower the pH. Other concentrations will require more treatment, however. One hazard of iron is bacterial interaction with iron. Various bacteria can react with ferrous (+2 charge) iron through an oxidation process. The resulting ferric (+3 charge) iron is insoluble. The ferric iron eventually will be surrounded by filamentous bacteria, forming the slime (gel) that clogs emitters. Chlorination is used to oxidize the ferrous iron. The resultant ferric iron is filtered before it can reach and clog the emitters.

If the water pH is high, concurrent acidification and chlorination may be required. Injection points of the two materials into the water stream should be at least 2 to 3 feet apart. *Acid and chlorine should never be combined in the same container.*

Concluding Statements

When using SDI systems, it is important to prevent clogging problems before they occur so the benefits of SDI can be reaped for many years. The best prevention plan includes an effective filtration and water treatment strategy. Depending on the water source and its quality, various combinations of sand separation, screen filtration, sand media filtration, chlorination, and acid injection may be required. Filtration equipment may be the single item of greatest cost when installing the SDI system. Resist the temptation to "cut corners." Good filtration will pay for itself by avoiding the chemical treatments, labor, or extra effort that are otherwise required to fix a system damaged because it was not adequately maintained.

Despite our filtration efforts, some materials will not be removed and will find their way into the dripline. To prevent the accumulation of those materials in the dripline and the resultant emitter clogging, the driplines should be flushed occasionally. Flow meters and pressure gauges should be checked periodically to assure that the system is operating correctly. If measured flow rates and pressure distributions indicate problems in the system, some reconditioning may be possible with chemical injection (including chlorine shock treatments), flushing, and other steps.

Profit margins for crops typically grown in the Great Plains are not as high as the profit margins for fruits and vegetables traditionally grown with SDI systems. To make SDI systems in the Great Plains economically more viable, they must have a long life. Prevention of clogging is therefore critical to the successful and economical use of SDI in the Great Plains.

References

Alam, M. 1996. Irrigation. Subsurface microirrigation. Colorado State University Cooperative Extension Publication No. 4.716. Ft. Collins. 3 pp.

Hanson, B., L. Schwankl, S. R. Grattan, and T. Pritchard. 1994. Drip irrigation for row crops. Water Management Series Publication 93-05. University of California Irrigation Program, Davis. 175 pp.

Lamm, F. R., G. A. Clark, M. Yitayew, R. A. Schoneman, R. M. Mead, and A. D. Schneider. 1997. Installation issues for SDI systems. ASAE Paper 972074 from ASAE, St. Joseph, MI. 6 pp.

Nakayama, F. S. and D. A. Bucks. 1986. Trickle irrigation for crop production. Elsevier Publishers, Amsterdam. 383 pp.